

## DESCRIPTION

## Method of Manufacturing Circuit Forming Board

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## Technical Field

The present invention relates to a method of manufacturing a circuit forming board used in electronic apparatuses.

## Background of the Invention

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As electronic apparatuses have had a reduced size and included dense arrangement in their packages, circuit-forming boards having electronic components mounted thereon employ double-sided and multi-layer boards which can have more circuits and more components mounted thereon.

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A conventional circuit forming board disclosed in Japanese Patent Laid-Open Publication No.6-268345 will be explained. Fig. 6 illustrates a method of manufacturing prepreg sheet 13, a material of the board. A fiber sheet, such as glass cloth 11, used as a reinforcing member is dipped into varnish 12, impregnating impregnation material containing solvent having thermosetting resin diluted therein, thus impregnating glass cloth 11 with a predetermined amount of varnish 12. In order to adjust the amount of varnish 12, varnish 12 is squeezed by rollers, and then, is heated to change into a semi-cured state (stage B). The glass cloth in the stage B containing varnish is cut into pieces having a predetermined size, thus providing prepreg sheets 13 as material of circuit forming boards.

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As shown in Fig. 6, prepreg sheet 13 is cut into a rectangle having longitudinal direction 202. The longitudinal direction 202 is oriented along a machine direction (MD), a direction in which glass cloth 11 is transferred.

Film is stuck onto each surface of prepreg sheet 13 by a method shown in Figs. 7 and 8.

Fig. 7 is a perspective view illustrating a process of sticking the film on prepreg sheet 13. Fig. 8 illustrates prepreg sheet 13 and film 14 seen along direction 204 in the process. Prepreg sheet 13 is introduced between films 14 along direction 201 (MD), i.e. the longitudinal direction 202, and then, films 14 are pressed onto prepreg sheet 13 by heated rollers 15, thereby heating and pressing prepreg sheet 13. Since the resin impregnated in prepreg sheet 13 is in the semi-cured state, the resin melts due to the heating, hence allowing film 14 to adhere temporarily onto prepreg sheet 13. Then, films 14 are cut into pieces having predetermined sizes along line 203, hence providing laminated prepreg sheet 16.

A method of manufacturing the circuit forming board will be described hereinafter. Figs. 9A-9G show sectional views of the circuit forming board for illustrating the method of manufacturing the board. Fig. 9A shows laminated prepreg sheet 16 including prepreg sheet 13 and films 14 adhering onto both surfaces of sheet 13. As shown in Fig. 9B, prepreg sheet 16 is pierced by a laser beam, thereby forming a via-hole 17. The hole 17 is then filled with conductive paste 18 by printing, as shown in Fig. 9C. Conductive paste 18 is formed by mixing metallic particles, such as copper, with thermosetting resin, such as epoxy resin. Then, as shown in Fig. 9D, films 14 are peeled off. Since a small amount of resin component of films 14 melting on the surfaces of prepreg sheet 13 to allow films 14 to be temporarily stuck onto prepreg sheet 13, films 14 can be peeled off easily. As shown in Fig. 9D, paste 18 projects from sheet 13 by the thicknesses of films 14 after the peeling of the films. Then, as shown in Fig. 9E, copper foils 19 are placed on upper and lower surfaces of sheet 13, and then is

hot-pressed by a hot presser, such as a vacuum hot presser. The resin component of sheet 13 melts and undergoes molding and curing steps, and then conductive paste 18 is compressed. As a result, copper foils 19 on both surfaces of sheet 13 are electrically connected to paste 18, as shown in Fig.

5 9F. Then, copper foils 19 are etched to have a predetermined pattern for forming circuit 20, as shown in Fig. 9G, thus providing a double-sided circuit forming board.

In the foregoing method, sheet 13 shown in Fig. 9D, upon having an uneven thickness, causes variation of a compressing rate of paste 18 at the  
10 hot-pressing, as shown in Figs. 9E and 9F. The variation causes variation of a resistance of paste 18 which connects circuits 20 on both surfaces of the circuit forming board, thereby adversely affecting quality and reliability of the board.

That is, via-hole 17 formed in a thick portion of prepreg sheet 13, as  
15 shown in Fig. 9D, reduces a compression rate of paste 18, hence increasing a resistance of paste 18.

On the contrary, via-hole 17 formed in a thin portion of sheet 13 increases the compression rate of paste 18, hence reducing a resistance of paste 18. As such, the compression rate actually varies from a standard  
20 rate estimated based on an amount of the metallic particles mixed with the thermosetting resin, hence reducing the reliability of the coupling.

If the circuit forming board is required to have equal resistances, for instance, for handling high frequency signals, it is undesirable to allow electric resistance of paste 18 to vary according to a position of the board.

25 Even after films 14 are stuck onto prepreg sheet 13 having a large variation of the thickness, the variation of the thickness of sheet 13 still remains, hence allowing the variation of the thickness of the sheet 13 to

remain even in laminated prepreg sheet 16. This problem also occurs in cases other than the case that glass cloth 11, a woven fabric, is employed as the material of prepreg sheet 13, i.e., the fiber sheet as the reinforcing member. This problem may occur in the case that unwoven fabric is employed. Woven fabric is impregnated with an amount of varnish 12 less than unwoven fabric. A larger amount of varnish 12 is accordingly attached at the surfaces of prepreg sheet 13, hence allowing the variation of the thickness of the woven fabric to affect electrical properties of conductive paste 18.

As thinner circuit forming boards have been recently demanded, glass cloth 11 becomes thin. This increases the amount of varnish 12 attached at the surface of prepreg sheet 13, hence making the above problem more serious.

In order to prevent the problem, it is essential that prepreg sheet 13 shown in Fig. 9A has an even thickness.

However, an accuracy limitation of manufacturing apparatuses limits flatness of the thickness of prepreg sheet 13 to a certain level when varnish 12 is squeezed with rollers, as shown in Fig. 6, and when films 14 are stuck onto both surfaces of sheet 13.

### Summary of the Invention

In a method of manufacturing a circuit forming board, a first sheet having a first direction is transferred in a second direction, so that the first direction of the first sheet is parallel to the second direction. Films are stuck onto both surfaces of the first sheet while transferring the first sheet in a third direction orthogonal to the first direction of the first sheet.

This method allows a connecting member, such as conductive paste, to

electrically couple between layers of the circuit forming board.

### Brief Descriptions of the Drawings

Fig. 1 is a perspective view illustrating a method of manufacturing a prepreg sheet in accordance with an exemplary embodiment of the present invention.

Figs. 2A-2C are perspective and sectional views of the prepreg sheet in accordance with the embodiment.

Fig. 3 is a perspective view illustrating the method of manufacturing the prepreg sheet in accordance with the embodiment.

Fig. 4 is a sectional view illustrating the method of manufacturing the prepreg sheet in accordance with the embodiment.

Figs. 5A-5G are sectional views of the circuit forming board for illustrating the method of manufacturing the board in accordance with the embodiment.

Fig. 6 is a perspective view illustrating a conventional method of manufacturing a prepreg sheet.

Fig. 7 is a perspective view illustrating the conventional method.

Fig. 8 is a side sectional view illustrating the conventional method.

Figs. 9A-9C are sectional views of the circuit forming board for illustrating the conventional method of manufacturing the board.

Figs. 10A-10C are perspective and sectional views of the conventional prepreg sheet.

### Detailed Description of Preferred Embodiment

According to experiments, causes of a variation of a thickness of conventional prepreg sheet 13 manufactured by a method shown in Fig. 6-8

were confirmed.

Conventional prepreg sheet 13 having an uneven thickness shown in Fig. 9A will be described. Fig. 10A is a perspective view of prepreg sheet 13. Fig. 10B is a sectional view of prepreg sheet 13 taken along line 10B-10B shown in Fig. 10A. Fig. 10C is a sectional view of prepreg sheet 13 taken along line 10C-10C shown in Fig. 10A.

Films 14 were peeled off from both surfaces of sheet 13 to observe the cross section of sheet 13. A larger variation of the thickness was found in the section shown in Fig. 10B taken along line 10B-10B shown in Fig. 10A. A smaller variation of the thickness was found in the cross section shown in Fig. 10C taken along line 10C-10C shown in Fig. 10A.

As shown in Fig. 6, glass cloth 11 impregnated with liquid varnish 12 is transferred in a machine direction (MD) 201 while varnish 12 is squeezed with rollers in order to adjust an amount of varnish 12 impregnated in the glass cloth. Along MD 201, a small variation of the amount of varnish 12 was found, namely, a variation of the thickness of sheet 13 was small. However, a large variation of the thickness of sheet 13 was found along a direction orthogonal to MD 201.

Fig. 1 shows a perspective view illustrating a method of manufacturing prepreg sheet 3 in accordance with an exemplary embodiment of the present invention. A fiber sheet used as a reinforcing member, such as glass cloth 1, is dipped into varnish 2, i.e. impregnating impregnation material formed by diluting thermosetting resin with solvent, and glass cloth 1 is impregnated with a predetermined amount of varnish 2. In order to adjust the amount of varnish 2 impregnated, varnish 2 is squeezed with rollers, and is then heated to be in a semi-cured state (stage B). The glass cloth in stage B containing varnish is cut into pieces having predetermined sizes, thus providing prepreg

sheet 3, a material of a circuit forming board.

As shown in Fig. 1, prepreg sheet 3 is cut into a rectangular shape having a short-side direction 102 oriented along the direction 101 in which glass cloth 1 is transferred, namely, a machine direction (MD).

5 Fig. 1 shows a single prepreg sheet 3; however, plural prepreg sheets 3 may be actually arranged in a row with taking into consideration about a width of glass cloth 1 and intervals of cutting. For example, glass cloth 1 having a width of about 1m provides two prepreg sheets 3 each having a long-side of 400 mm and a short-side of 300 mm wide arranged in a row by  
10 cutting glass cloth 1.

Fig. 2A is a perspective view illustrating prepreg sheet 3 thus manufactured. Fig. 2B is a sectional view of prepreg sheet 3 taken along line 2B-2B shown in Fig. 2A. Fig. 2C is a sectional view of prepreg sheet 3 taken along line 2C-2C shown in Fig. 2A. A variation of the thickness along  
15 a short-side direction shown in Fig. 2B is smaller than a variation of the thickness along the long-side direction shown in Fig. 2C.

Next, films 4 are pressed onto prepreg sheet 3 with heated rollers 5A and 5B, and are stuck onto sheet 3, as shown in Figs. 3 and 4. While films 4 are adhered, the long-side direction 103 of sheet 3 matches MD 104, namely,  
20 the direction in which sheet 3 is transferred.

Factors, such as variations of diameters of heated rollers 5A and 5B, a pressure applied to them, a heating temperature, and parallelism between rollers 5A and 5B tend to disperse along an axial direction 105 of the heated rollers. As shown in Fig. 3, axial direction 105 of rollers 5A and 5B matches  
25 short-side direction 102 of prepreg sheet 3, thereby reducing the width of sheet 3 with respect to MD 104 while films 4 are stuck onto sheet 3. This arrangement reduces adverse effects due to the variations of rollers 5A and

5B, hence increasing adhesion quality of films 4 onto sheet 3.

According to the embodiment, MD 101 for manufacturing prepreg sheet 3 is orthogonal to MD 104 for sticking film 4 with respect to prepreg sheet 3.

This arrangement reduces the variation of the thickness of sheet 3.

5 Variations of the thickness, the heating temperature, and a pressure along MD 101 and MD 103 are small during the manufacturing of prepreg sheet 3 and the sticking of films 4. However, the variations are large along a direction orthogonal to MD 101 and MD 103. Therefore, if MD 101 matches MD 103 with respect to prepreg sheet 3 during the manufacturing  
10 of the prepreg sheet and the sticking of films 4, the variation of the thickness of sheet 3 remains until the circuit forming board is manufactured.

However, if MD 101 for manufacturing prepreg sheet 3 is orthogonal to MD 103 for sticking films 4 with respect to prepreg sheet 3, the variations occurring in the both processes are cancelled, hence providing sheet 3 in  
15 laminated prepreg sheet 6 with a uniform thickness.

In other words, the variation of the thickness due to the variation of the amount of varnish 12 attached to fiber sheet 3 during the manufacturing of sheet 3 is reduced by heating and pressing prepreg sheet 6 during the sticking of films 4.

20 Next, a method of manufacturing the circuit forming board in accordance with the embodiment will be described with reference to Figs. 5A-5G. Laminated prepreg sheet 6, a material of the board, shown in Fig. 5A includes prepreg sheet 3 and films on both surfaces of sheet 3. As shown in Fig. 5B, sheet 3 is pierced by a laser beam, thereby forming via-holes 7, and then, via-holes 7 are filled with conductive paste 8 by printing.  
25 Conductive paste 8 is formed by mixing metallic particles, such as copper, with thermosetting resin, such as epoxy resin.



Then, as shown in Fig. 5D, films 4 are peeled off from sheet 6. Since just a small amount of resin component of films 4 melting on the surfaces of sheet 3 to allow films 4 to be temporarily stuck onto sheet 3, films 4 can be peeled off easily. As shown in Fig. 5D, paste 8 projects from sheet 3 by  
5 thicknesses of films 4 after the peeling. Next, as shown in Fig. 5E, copper foils 9 are placed on upper and lower surfaces of sheet 3, and are then hot-pressed by a hot presser, such as a vacuum hot presser. The resin component of sheet 3 melts and undergoes molding and curing steps, and then, conductive paste 8 is compressed. As a result, copper foils 9 on both  
10 surfaces of sheet 3 are electrically connected to paste 8, as shown in Fig. 5F. Then, copper foils 9 are etched to have predetermined pattern for forming circuit 10, as shown in Fig. 5G, thus providing a double-sided circuit forming board.

Films 4 were peeled off from laminated prepreg sheet 6 shown in Fig. 5A, and then, the thickness of prepreg sheet 3 was measured. It was  
15 observed that the sheet has a uniform thickness also from the appearance of films 4 of laminated sheet 6. Since having uniform surfaces, the sheet 3 stabilizes an electric resistance of conductive paste 8 becomes stable, and can be handled easily during the forming of the via-holes, thus having stable  
20 dimensions in each process.

According to the embodiment, prepreg sheet 3, a board material is made of woven fabric, i.e. a fiber sheet, such as regular glass cloth 1, or non-woven fabric, impregnated with thermosetting resin in stage B. The fiber sheet can employ organic fabric, such as aramid, instead of the glass  
25 cloth.

Varnish 2 can be replaced with inorganic material which is cured to provide a rigid board, other than the thermosetting resin. A film base or a

film in stage B that does not include fiber sheet, the reinforcing member, may be used as prepreg sheet 3.

Fiber sheet 1, the reinforcing member, may employ material containing woven fabric and unwoven fabric mixed with the woven fabric, for example, may employ material including two glass fiber sheets and non-woven glass fiber sheet between the two sheets.

The thermosetting resin according to this embodiment may be one of epoxy resin, epoxy-melamine resin, unsaturated polyester resin, phenol resin, polyimide resin, cyanate-based resin, ester cyanate resin, naphthalene resin, urea resin, amino resin, alkyd resin, silicon resin, furan-based resin, polyurethane resin, aminoalkyd resin, acrylic resin, fluoro resin, polyphenylene ether resin, ester cyanate resin. The thermosetting resin may be thermosetting resin composition formed by mixing plural resins selected from the foregoing resins, or thermosetting resin composition modified by thermoplastic resin. Fire-retardant or inorganic filler may be added to the thermosetting resin if necessary.

According to this embodiment, the method of manufacturing a double-sided circuit forming board is described. Processes of this method may be repeated for manufacturing a multi-layer circuit forming board, that is, circuit boards including prepreg sheets filled with conductive paste may be attached to each other, thereby providing a multi-layer circuit board.

Conductive paste 8 for coupling copper foils 9 is formed by mixing conductive particles, such as copper powder, with thermosetting resin containing curing agent. Paste 8 may be formed by mixing the conductive particles with polymer material having an appropriate viscosity which is discharged into the board material at the heat-pressing. The paste may be formed by mixing the conductive particles with solvent.

Instead of the conductive paste, post-shaped conductive projections formed by plating may be used. Conductive particles having large diameters and not formed into paste may be placed between copper foils 9 for coupling.

5        Boards are pierced for plating after the heat-pressing similarly to an ordinary multi-layer printed circuit board, so that layers of the boards can be coupled. Such boards may be manufactured by the method according to the embodiment.

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#### Industrial Applicability

The circuit forming board according to the present invention employs coupling member, such as conductive paste, between respective layers, hence providing stable and quality electrical connection between copper foils on both surfaces of the board.